

### Claims

1. A method of making a multilayer article, comprising:

depositing a first material on the surface of a metal substrate to form a biaxially textured seed layer of the first material, the first material being deposited under reducing conditions

5 relative to the metal substrate; and

epitaxially depositing a second material over the seed layer wherein the second material is deposited from a solution-based precursor to form a second layer under second conditions that are more oxidizing than the reducing conditions used in the deposition of the first material, and

10 wherein the atmosphere of the second conditions comprises a water partial pressure in the range of about 4 torr to about 40 torr.

2. A method of making a multilayer article, comprising:

depositing a first material on the surface of a metal substrate to form a biaxially textured seed layer of the first material, the first material being deposited under reducing conditions relative to the metal substrate; and

15 epitaxially depositing a ceria layer having a termination plane over the seed layer, at least 25% of the termination plane of the ceria layer comprising the (001) plane,

wherein the ceria layer is deposited from a solution-based precursor under second conditions that are more oxidizing than the reducing conditions used in the deposition of the first material, and

20 wherein the atmosphere of the second conditions comprises a water partial pressure in the range of about 4 torr to about 40 torr.

3. The method of claim 1 or 2, wherein the reducing conditions for depositing the first material comprise an oxygen partial pressure less than about  $10^{-15}$  atm.

4.The method of claim 1 or 2, wherein the reducing conditions for depositing the first material comprise an oxygen partial pressure less than about  $10^{-21}$  atm.

5.The method of claim 1 or 2, wherein the reducing conditions for the deposition of the first layer comprises forming gas.

5           6.The method of claim 5, wherein the reducing conditions for the first layer comprise heating at a temperature in the range of about 400°C to about 1200°C.

7.The method of claim 1 or 2, wherein reducing conditions for the first layer comprise heating in an atmosphere of hydrogen and water.

8.The method of claim 7, wherein the ratio of the partial pressure of water to the partial  
10   pressure of hydrogen during formation the first material is in the range of about 0.1 to about 0.5 at a temperature of about 800°C to about 1100°C.

9.The method of claim 1 or 2, wherein the first layer is epitaxially deposited.

10. The method of claim 1 or 2, wherein the first material is deposited using a  
technique selected from the group consisting of sputtering, e-beam deposition, ion beam assisted  
15   deposition, physical vapor deposition, physical laser deposition, chemical vapor deposition, and metal organic deposition.

11. The method of claim 1 or 2, wherein the first material is selected from the group consisting of metals, metal oxides, and metal nitrides that have crystalline surfaces that are stable under the second deposition conditions that are oxidizing relative to the underlying substrate.

12. The method of claim 1 or 2, wherein the first material is selected from the group consisting silver, gold, palladium, nickel,  $\text{CeO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{TbO}_x$ ,  $\text{GaO}_x$ , YSZ,  $\text{LaAlO}_3$ ,  $\text{SrTiO}_3$ ,  $\text{Gd}_2\text{O}_3$ ,  $\text{LaNiO}_3$ ,  $\text{LaCuO}_3$ ,  $\text{NdGaO}_3$ ,  $\text{NdAlO}_3$ ,  $\text{MgO}$ ,  $\text{CaF}_2$ ,  $\text{AlN}$ ,  $\text{NbN}$ ,  $\text{TiN}$ ,  $\text{VN}$ ,  $\text{ZrN}$ ,  $\text{YN}$ ,  $\text{NiO}$ ,  $\text{Ag}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SmBa}_2\text{Cu}_3\text{O}_x$ ,  $\text{MgF}_2$ ,  $\text{LaMnO}_3$ ,  $\text{La}_{0.66}\text{Ca}_{0.33}\text{MnO}_3$ ,  $\text{La}_{0.66}\text{Sr}_{0.33}\text{MnO}_3$ ,  $\text{La}_{0.66}\text{Ba}_{0.33}\text{Mn}_3$ ,  
5  $\text{La}_2\text{Zr}_2\text{O}_7$ ,  $\text{Gd}_2\text{Zr}_2\text{O}_7$ ,  $\text{Ba}_2\text{Zr}_2\text{O}_7$  and doped compounds thereof.

13. The method of claim 1 or 2, wherein the second conditions for the second layer comprise an oxygen partial pressure in the range of about  $10^{-21}$  atm to about  $10^{-12}$  atm.

14. The method of claim 1 or 2, wherein the water partial pressure is in the range of about 4 torr to about 25 torr.

10 15. The method of claim 1 or 2, wherein the water partial pressure is in the range of about 10 torr to about 25 torr.

16. The method of claim 1 or 2, wherein the second conditions comprise heating the second material in an atmosphere comprising hydrogen and water.

15 17. The method of claim 16, wherein second conditions comprise a total pressure in the range of 30 torr to 760 torr and a water partial pressure in the range of about 4 torr to about 40 torr and a hydrogen partial pressure in the range of about 20 torr to about 50 torr, the balance being an inert carrier gas.

18. The method of claim 17, wherein the water partial pressure is in the range of about 4 torr to about 25 torr.

19. The method of claim 16, wherein the ratio of the partial pressure of water to the partial pressure of hydrogen in deposition the second material is in the range above about 0.1 to about 1 at a temperature of about 800°C to about 1100°C.

20. The method of claim 16, wherein said second conditions comprise heating at a  
5 temperature about 700°C to about 1200°C.

21. The method of claim 1, wherein the second material forms a buffer layer.

22. The method of claim 1, wherein the second material is selected from the group of metal oxides consisting of CeO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, TbO<sub>x</sub>, GaO<sub>x</sub>, YSZ, LaAlO<sub>3</sub>, SrTiO<sub>3</sub>, Gd<sub>2</sub>O<sub>3</sub>, LaNiO<sub>3</sub>, LaCuO<sub>3</sub>, NdGaO<sub>3</sub>, NdAlO<sub>3</sub>, MgO, NiO, Ag, Al<sub>2</sub>O<sub>3</sub>, SmBa<sub>2</sub>Cu<sub>3</sub>O<sub>x</sub>, MgF<sub>2</sub>, LaMnO<sub>3</sub>,  
10 La<sub>0.66</sub>Ca<sub>0.33</sub>MnO<sub>3</sub>, La<sub>0.66</sub>Sr<sub>0.33</sub>MnO<sub>3</sub>, La<sub>0.66</sub>Ba<sub>0.33</sub>Mn<sub>3</sub>O<sub>3</sub>, La<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub>, Gd<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub>, Ba<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub>, and Y<sub>2</sub>Ce<sub>2</sub>O<sub>7</sub> and doped compounds thereof.

23. The method of claim 1, wherein the second layer is deposited to a thickness of about five nanometers to about 300 nm.

24. The method of claim 2, wherein the ceria layer is deposited to a thickness of about  
15 five nanometers to about 300 nm.

25. The method of claim 1, wherein the second layer has a surface smoothness in the range of about 1nm to about 1 nm rms.

26. The method of claim 2, wherein at least 75% of the termination plane of the CeO<sub>2</sub> layer comprises the (001) plane.

27. The method of claim 1, further comprising depositing one or more intermediate layers between the first seed layer and the second material layer.

28. The method of claim 2, further comprising depositing one or more intermediate layers between the first seed layer and the ceria layer.

5           29. The method of claim 27 or 28, wherein the intermediate layer is epitaxially deposited from a solution-based precursor under third conditions that are more oxidizing than the reducing conditions used in the deposition of the first material, and the third conditions comprise a water partial pressure in the range of about 4 torr to about 40 torr.

10           30. The method of claim 27 or 28, wherein the intermediate layer is deposited using a technique selected from the group consisting of sputtering, e-beam deposition, ion beam assisted deposition, physical vapor deposition, physical laser deposition, chemical vapor deposition, and metal organic deposition.

31. The method of claim 1, further comprising depositing a cap material as a layer on the second material.

15           32. The method of claim 2, further comprising depositing a cap material as a layer on the ceria layer.

20           33. The method of claim 31 or 32, wherein the cap layer is epitaxially deposited from a solution-based precursor under third conditions that are more oxidizing than the reducing conditions used in the deposition of the first material, and the third conditions comprise a water partial pressure in the range of about 4 torr to 40 torr.

34. The method of claim 31 or 32, wherein the cap layer is deposited using a technique selected from the group consisting of sputtering, e-beam deposition, ion beam assisted deposition, physical vapor deposition, physical laser deposition, chemical vapor deposition, and metal organic deposition.

5           35. The method of claim 1, further comprising depositing a superconductor material on the second deposited layer.

36. The method of claim 2, further comprising depositing a superconductor material on the CeO<sub>2</sub> layer.

10           37. The method of claim 35 or 36, wherein the superconductor material comprises a rare earth oxide superconductor material.

38. The method of claim 35 or 36, wherein the rare earth oxide superconductor material comprises YBCO.

15           39. The method of claim 1 or 2, wherein the metal substrate is selected from the group consisting of nickel, silver, copper, zinc, aluminum, iron, chromium, vanadium, palladium, molybdenum and their alloys.